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LABORATORY AIRFLOW CONTROL VALVE FUNDAMENTALS

By Jarvis Penner,
– Product Manager, Critical Controls

The control of air distribution in modern laboratories is typically accomplished by using air terminal units. An air terminal unit will regulate the volume of conditioned air from the central air handling device to maintain thermal conditions and minimum fresh air volumes in the occupied space. In laboratories, room pressure is also controlled using the air terminal. The selection of air terminals is a critical component of the overall laboratory HVAC system and has a direct impact on the turndown, operating pressure, and acoustics of the space. This article provides an overview of the differences between a typical blade damper terminal unit and a venturi valve.

MECHANICAL OPERATION

A venturi valve is a mechanically pressure-independent control device that utilizes a venturi-shaped housing containing a cone with an internal spring to mechanically compensate for pressure changes in the system. A rise in system pressure increases the force against the cone, compressing the spring so that the cone travels deeper into the valve throat. As a result, the open area within the valve is reduced to maintain the preset flow at the higher pressure. A decrease in pressure allows the spring to extend, driving the cone out of the valve throat. In turn, the open area within the valve increases to maintain the preset flow at the lower pressure.

Since the venturi valve is mechanically pressure-independent, the relationship between airflow and cone position can be mapped to the controller to provide flow feedback without the use of airflow measuring devices in the airstream.

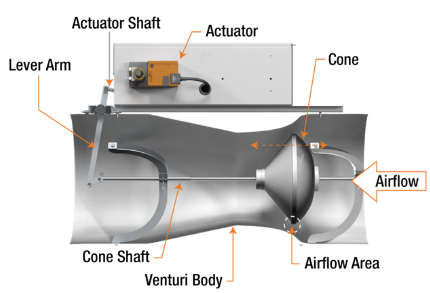
A blade damper is inherently a pressure-dependent control device. To maintain airflow as the system pressure changes, a blade damper must be connected to an airflow controller to modulate the damper position. As the pressure in the system increases, the controller will close the damper to maintain the flow setpoint. As the pressure in the system decreases, the controller will open the damper to maintain the flow setpoint. A typical blade damper requires direct airflow measurement using in-stream flow sensors to provide a signal to the controller.

OPERATING PRESSURE

Venturi valves have defined operating pressure ranges where pressure independence is achievable. The ranges are typically classified as low or medium pressure. Minimum operating pressure or drop is the value at which the spring can no longer extend to position the cone to maintain the preset flow. The minimum operating pressure is 0.3” W.C. for low-pressure valves and 0.6” W.C. for medium-pressure valves. Maximum operating pressure or drop is the value at which the spring can no longer compress to maintain the preset flow. The maximum operating pressure is 3.0” W.C. for both low- and medium-pressure valves.

Blade damper minimum pressure is defined by the pressure drop across the device with the damper fully open at the rated flow. Blade damper terminals commonly operate down to 0.01” W.C. The maximum pressure drop is typically defined as the value at which the airflow becomes difficult to control and can be in excess of 3.0” W.C.

Venturi Valve



Single Blade Damper

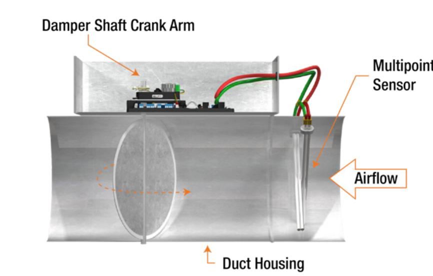


Diagram showing the mechanical components of a venturi valve and single blade damper

TURNDOWN

Airflow turndown is frequently used to express the airflow control range without the need to have specific minimum and maximum airflow rates. Blade damper control valves typically have a larger airflow capacity than a venturi air valve of the same diameter, but the turndown ratio is reduced due to the increase in minimum airflow. As shown in **Figure 1**, the turndown ratio of the venturi valve can be as high as 20:1 compared with the 6:1 ratio of a conventional blade damper valve.

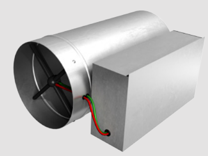
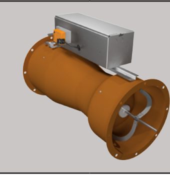
Valve Size	Conventional Valves (> 0.01" W.C.)			Low Pressure Venturi (0.3" - 3.0" W.C.)			Medium Pressure Venturi (0.6" - 3.0" W.C.)		
	Min. Flow (CFM)	Max. Flow (CFM)	**Turndown Ratio**	Min. Flow (CFM)	Max. Flow (CFM)	**Turndown Ratio**	Min. Flow (CFM)	Max. Flow (CFM)	**Turndown Ratio**
Size 8	160	800	**5:1**	35	500	**14:1**	35	700	**20:1**
Size 10	225	1350	**6:1**	50	550	**11:1**	50	1000	**20:1**
Size 12	350	2100	**6:1**	90	1200	**13:1**	90	1500	**16:1**
Size 14	500	3000	**6:1**	200	1400	**7:1**	200	2500	**12:1**
Product									

Figure 1 - Turndown comparison between blade dampers and venturi valves

AIRFLOW ACCURACY

Venturi valve airflow accuracy depends entirely on the flow-versus-position relationship of the valve that is completed during factory calibration. Venturi valves typically have airflow accuracies within +/- 5% of flow signal. The stable opening characteristic of venturi valves allows for high-resolution control at low flows as shown in **Figure 2**. Venturi valves do not have straight inlet or outlet requirements to maintain airflow accuracy but only require the device to be within the operable pressure range.

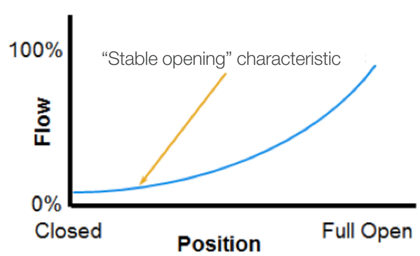


Figure 2 - Flow characteristics of the venturi valve

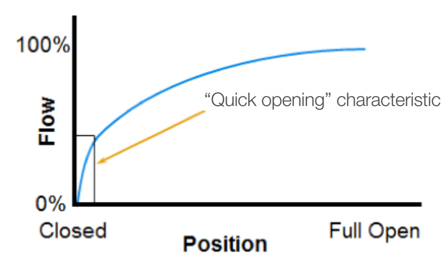


Figure 3 - Flow characteristics of the blade damper control valve

Blade damper airflow accuracy depends on the accuracy of the flow measuring sensor used for control. These flow measuring sensors typically require several duct diameters of straight duct leading into and out of the device to provide smooth laminar flow. The transducer error can also negatively impact the accuracy of airflow measurement at low flows. An example using a typical HVAC transducer with 1" W.C. range and error of 1% full scale is shown in **Figure 4**. In addition, the quick opening characteristic of blade dampers makes high-resolution control at low flows difficult, as shown in **Figure 3**.

CFM	Actual VP*	Transducer Error	Measured VP	Measured CFM	Error
1000	0.452	0.01	0.462	1011	1%
500	0.113	0.01	0.123	521	4%
200	0.018	0.01	0.028	249	25%
100	0.004	0.01	0.014	179	79%

*Size 10 blade damper control valve; K-Factor = 1487

Figure 4 - Airflow transducer accuracy chart

SOUND

Venturi valves will typically generate higher discharge and radiated sound power levels when compared to blade dampers. This is a result of the internal cone continually restricting a portion of the open area within the venturi valve. Sound attenuation may need to be considered if acoustics is a concern in the design.

SUMMARY

The venturi valves and blade dampers have very different mechanical characteristics that can provide advantages depending on the application. It is critical to understand the mechanical limitations of the device prior to writing job specifications. The next Engineering Update will focus on how the mechanical operation of a venturi valve affects speed of response and how changes to laboratory standard ANSI Z9.5 affect what valve type should be specified.

Valve Size	Flow (CFM)**	Terminal Discharge NC Value*	Terminal Radiated NC Value *	Venturi Discharge NC Value*	Venturi Radiated NC Value*
Size 8	400	21	21	31	23
Size 10	750	25	21	37	29
Size 12	900	27	21	32	24
Size 14	1500	26	26	41	44

*NC values are calculated based on typical attenuation values outlined in Appendix E, AHRI Standard 885-2008

** Flow measurements taken at 1.5" w.c. pressure drop

Figure 5 - Valve data obtained in accordance with AHRI Standard 880-2011 and ASHRAE Standard 130-2008